

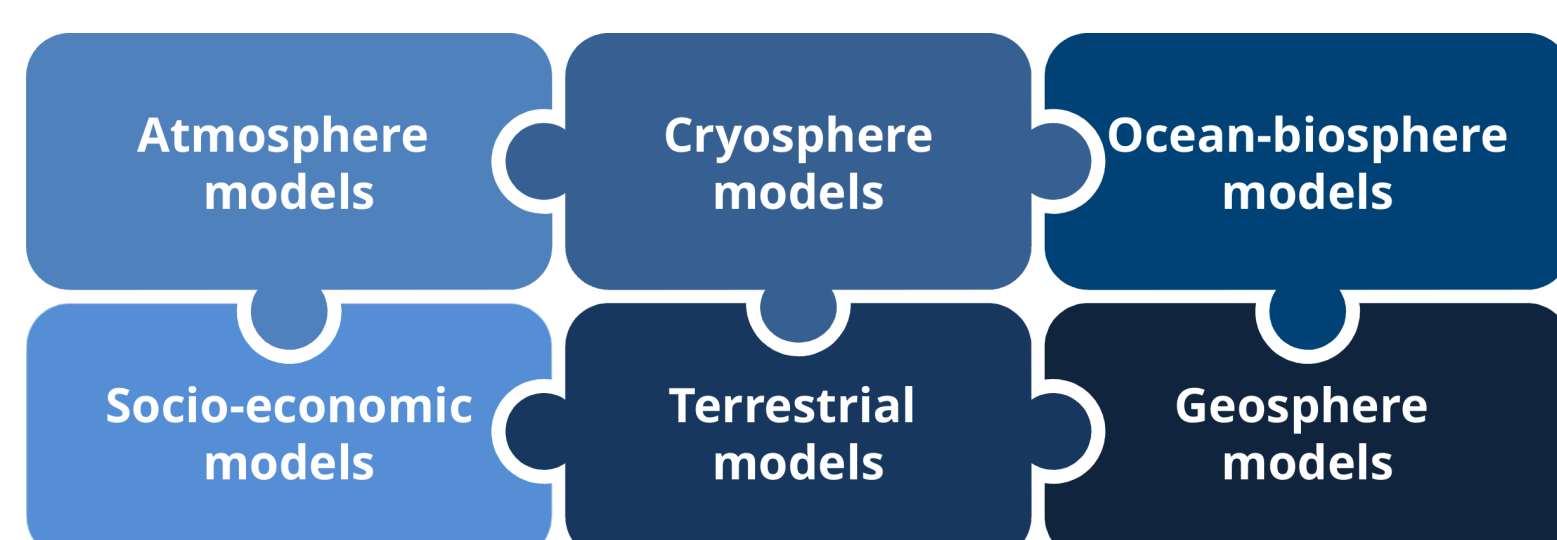
# esm-interfaces: Towards a Modular ESM Coupling Approach

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## Advanced Earth System Modelling Capacity (ESM)

- Development of a flexible framework for the effective coupling of Earth System Model (ESM) components.



## esm-interfaces

### Objectives

- To enable a modular, flexible and configurable ESM coupling.

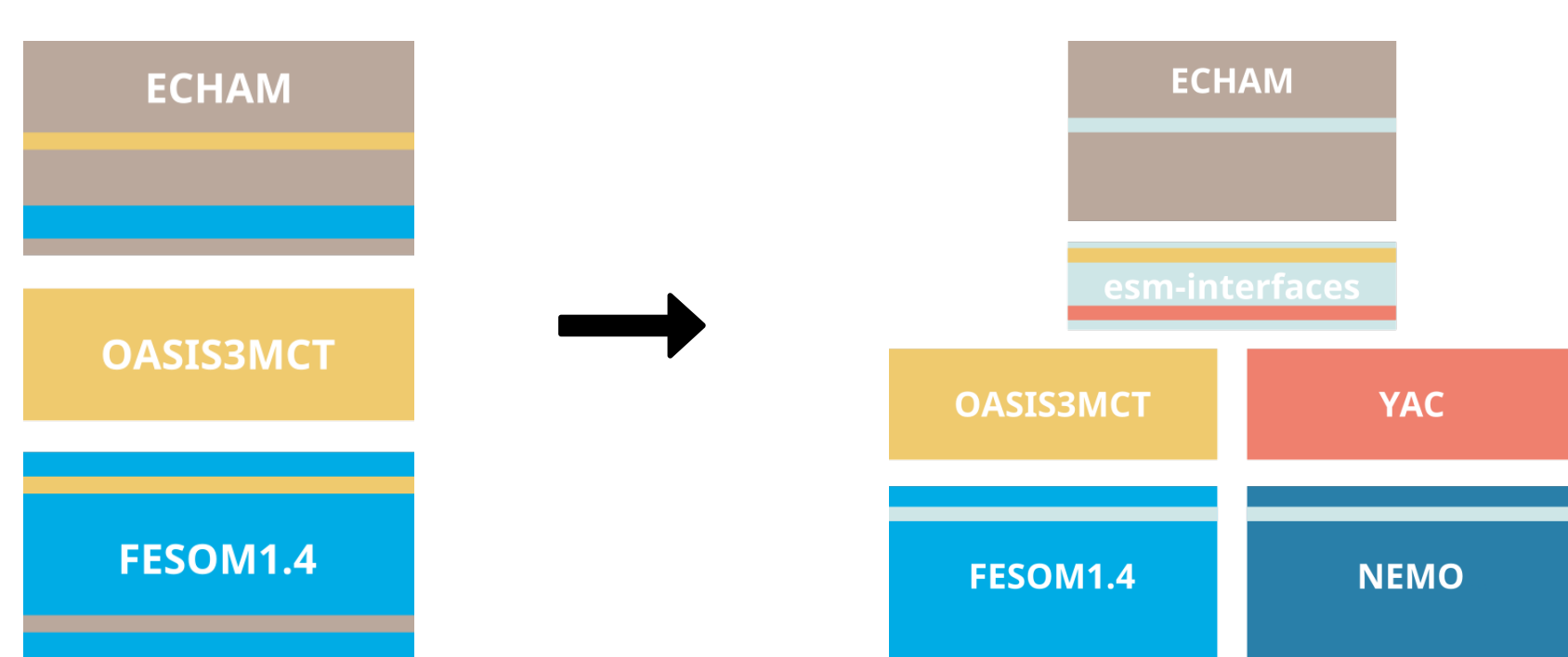


Figure: Modular ESM setup using esm-interfaces

### Features

- Fortran library;
- Provides wrapper procedures to different model couplers;
- Provides derived data types, type-bound procedures ("object-oriented" approach) to model components.

## Case Example: Modular AWI-CM Prototype

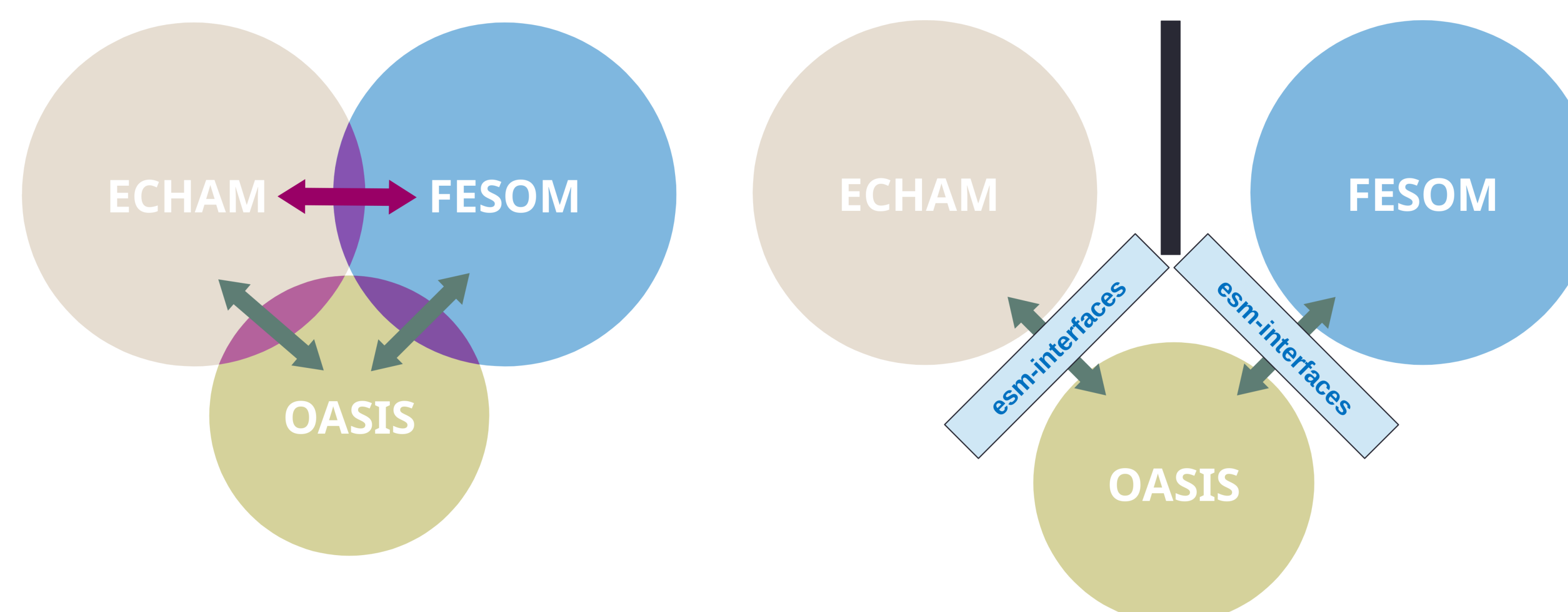


Figure: Implementation scheme of esm-interfaces into AWI-CM 1 [4] (FESOM 1.4 [1], ECHAM6 [5], OASIS3MCT [6]) and esm-interfaces library (Wieters et al., in prep.)

### Main Development Steps for Prototype

**Task 1:** Enable a coupler independent approach:

- Wrap direct calls to coupler modules and procedures by esm-interfaces.

**Task 3:** Enable a configurable/non static ESM coupling setup:

- Declaration of coupling fields by each component (key/value dictionary);
- Control ESM coupling setup via namelist and keywords;
- Write coupler dependent configuration files (e.g. namcouple for OASIS3MCT);
- Create instances of coupling field objects;
- Call generic coupling procedures and methods from esm-interfaces library.

**Task 2:** Detect programme code as possible generic procedures that are independent of coupler and component.

**Task 4:** Remove inter-component dependencies:

- Replace component specific code fragments and pre-compiler flags;
- Field specific procedures (esm-dict);
- Model specific procedures (namelist).

### Outlook and Open Tasks

- WIP: Implementation into FESOM2 [2];
- Implementation of YAC [3];
- Performance analysis;
- Code- and user-documentation.

## Code Snippets

```

Task 1:
USE mod_oasis      USE esm_interface
CALL oasis_get(...) CALL esm_couple_get(...)

Task 2:
SUBROUTINE grids_writing(...)
...
CALL oasis_write_grid (...)

SUBROUTINE esm_cpl_create_masks(...) ! Coupler independent
SUBROUTINE esm_couple_set_grid(...) ! Coupler dependent

Task 3:
esm_dict%portid(1) = 'tsw'
esm_dict%description(1) = 'sea surface temperature'
esm_dict%ptr_to_port(1)%p => tsw
esm_dict%ptr_to_fct(1)%pfct => function_tsw

CALL esm_declare_needed_vars(o2astreams,o2aports)

SUBROUTINE esm_declare_needed_vars(inputvars,inputports)
...
ALLOCATE(needed_input_fields(SIZE(inputvars)))
DO i=1,SIZE(inputvars)
  needed_input_fields(i)%identifier = TRIM(inputvars(i))
  needed_input_fields(i)%port      = inputports(i)
  needed_input_fields(i)%model     = model_info%model_name
  needed_input_fields(i)%in_or_out = 1 ! 1=in, 0=out
  CALL esm_dict%get((TRIM(inputports(i)),dict_idx)
  needed_input_fields(i)%portarr => esm_dict%ptr_to_port(dict_idx)%p
ENDDO
...
END SUBROUTINE

```

## Contact Information

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[1] S. Danilov, G. Kivman, and J. Schröter. "A finite-element ocean model: principles and evaluation". In: *Ocean Modelling* 6.2 (2004), pp. 125–150. ISSN: 1463-5003. DOI: [https://doi.org/10.1016/S1463-5003\(02\)00063-X](https://doi.org/10.1016/S1463-5003(02)00063-X).

[2] S. Danilov, D. Sidorenko, Q. Wang, and T. Jung. "The Finite-volume Sea Ice-Ocean Model (FESOM2)". English. In: *GEOSCIENTIFIC MODEL DEVELOPMENT* 10.2 (2017), pp. 765–789. ISSN: 1991-959X. DOI: {10.5194/gmd-10-765-2017}.

[3] M. Hanke, R. Redler, T. Hofeld, and M. Yastremsky. "YAC 1.2.0: new aspects for coupling software in Earth system modelling". In: *GEOSCIENTIFIC MODEL DEVELOPMENT* 9.8 (2016), 2755–2769. ISSN: 1991-959X. DOI: {10.5194/gmd-9-2755-2016}.

[4] D. Sidorenko, T. Rackow, T. Jung, T. Semmler, et al. "Towards multi-resolution global climate modeling with ECHAM6-FESOM. Part I: model formulation and mean climate". In: *Climate Dynamics* 44.3 (2015), pp. 757–780. ISSN: 1432-0894. DOI: 10.1007/s00382-014-2290-6.

[5] B. Stevens, M. Giorgetta, M. Esch, T. Mauritsen, et al. "Atmospheric component of the MPI-M Earth System Model: ECHAM6". In: *Journal of Advances in Modeling Earth Systems* 5.2 (2013), pp. 146–172. DOI: 10.1002/jame.20015. eprint: <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/jame.20015>.

[6] S. Valcke. "The OASIS3 coupler: a European climate modelling community software". In: *Geoscientific Model Development* 6.2 (2013), 373–388. ISSN: 1991-959X. DOI: {10.5194/gmd-6-373-2013}.